9.0 GROUNDWATER PROTECTION

The primary mission of the U.S. Department of Energy, Nevada Operations Office (DOE/NV) at the Nevada Test Site (NTS) has been the testing of nuclear devices and their components. The DOE/NV's Environmental Protection Policy Statement outlines a general policy of preventing pollutants generated by such tests from reaching groundwater, but it also recognizes that some options for groundwater protection are precluded by an increased risk of atmospheric releases and potential violation of international agreements. Therefore, the DOE/NV groundwater protection policy represents a balance between strict compliance with atmospheric release agreements and minimization of groundwater impacts. Groundwater protection is implemented by various programs that address compliance with regulatory requirements, minimization of waste streams, closure and monitoring of waste facilities, remedial investigations, groundwater monitoring, and environmental research.

The Nevada Environmental Restoration Project (ERP) goals are to safeguard the public's health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. In 1996, DOE formalized an agreement with the state for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. Investigation and cleanup activities continued on the NTS and Nellis Air Force Range Complex, and at offsite locations in the state of Nevada and other states.

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the U.S. Environmental Protection Agency (EPA) under an Interagency Agreement. In 1996, groundwater was monitored on and around the NTS, at five sites in other states, and at two off-NTS locations in Nevada to detect any radioactivity that may be related to previous nuclear testing activities. Although tritium initially seeped from two of the offsite tests, the tritium levels in wells at both these sites have been decreasing and were well below the National Primary Drinking Water Regulation levels. NTS supply wells were monitored for gross alpha and beta activity as well as for tritium levels.

9.1 EXISTING GROUNDWATER CONDITIONS

HYDROGEOLOGY OF THE NTS

The NTS has three general water-bearing units: the lower carbonate aquifer, volcanic aquifers, and valley-fill aquifers. The water table occurs variably in the latter two units while groundwater in the lower carbonate aquifer occurs under confined conditions. The depth to the saturated zone is highly variable, but is generally at least 150 m (approximately 500 ft) below the land surface, and is often more than 300 m (approximately 1000 ft). The hydrogeologic units, at the NTS, occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Chapter 2, Figure 2.9, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but what is known about the basin hydrology is summarized below.

Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin and discharges along a spring line in Ash Meadows, south of the NTS. Most of the western NTS is in the Alkali Flat-Furnace Creek Subbasin with discharges occurring by evapotranspiration at Alkali Flat and by spring flow near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin which discharges by evapotranspiration in Oasis Valley. Some underflow from the subbasin discharge areas probably travels to springs in Death Valley. Regional groundwater flow is from the upland recharge areas in the north and east toward discharge areas in Ash Meadows and Death Valley, southwest of the NTS. Because of large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions may be radically different from the regional trend (Laczniak et al., 1996).

HYDROGEOLOGY OF NON-NTS UNDERGROUND TEST SITES

The following descriptions of the hydrogeology of non-NTS underground test sites are summarized from Chapman and Hokett, 1991.

FALLON, NEVADA

The Project SHOAL site is located in the granitic uplift of the Sand Spring Range. The highland area around the site is a regional groundwater recharge area, with regional discharge occurring to the west in Fourmile Flat and Eightmile Flat, and to the northeast in Dixie Valley. Evidence suggests that a groundwater divide exists northwest of the site and that the main component of lateral movement of groundwater near the site is southeast toward Fairview Valley. Groundwater in Fairview Valley moves north to the discharge areas in Dixie Valley. Groundwater in Fairview Valley occurs in three separate alluvial aquifers that are separated by clay aquitards. Ground-water flow velocities through the granite to the alluvial aquifers of Fairview Valley are calculated to be very low (Chapman and Hokett 1991).

BLUE JAY, NEVADA

The Project FAULTLESS site is located in a thick sequence of alluvial material underlain by volcanic rocks in the northern portion of Hot Creek Valley. Recharge to the alluvial aquifer and volcanic aquifer occurs in the higher mountain ranges to the west, with groundwater flowing toward the east-central portion of the valley, and discharging by evapotranspiration and underflow to Railroad Valley.

AMCHITKA ISLAND, ALASKA

The groundwater system of Amchitka Island is typical of an island-arc chain with a freshwater lens floating on seawater in fractured volcanic rocks. Active freshwater circulation occurs by precipitation, recharging the water table with a curving flow path downward in the interior of the island and upward flow near the coast. Generally, the hydraulic gradient is from the axis of the island toward the coast. Groundwater travel times have been estimated to be between 23 and 103 years from the test cavities to the Bering Sea.

RIO BLANCO, COLORADO

Project RIO BLANCO is located in the Fort Union and Mesa Verde sandstones in the Piceance Creek Basin. Three aquifers comprise the majority of the groundwater resources: a shallow alluvial aquifer, the upper "A" potable aquifer, and the lower "B" saline aquifer. The "A" and "B" aquifers are separated by the Mahogany Oil Shale aquitard. These aquifers lie well above the test depth. The alluvial aquifer is the primary source of groundwater in the area with flow to the northeast toward the Piceance Creek. Recharge to the alluvial aquifer occurs by downward infiltration of precipitation and surface water, and by upward leakage from underlying aquifers. The "A" aquifer is larger in areal extent than the overlying alluvial aquifer with the permeability in the "A" aquifer controlled by a vertical fracture system. The "B" aquifer exhibits minimal communication with the "A" aquifer.

GRAND VALLEY, COLORADO

Project RULISON is located in the Mesa Verde Sandstone which is overlain by alluvium, the Green River Formation (shale and marlstone), the Wasatch Formation (clay and shale), and the Ohio Creek Formation (conglomerate). The direction of groundwater flow is thought to be northward. The principal groundwater resources of the area are in the alluvial aquifer, which is separated from the test horizon by great thicknesses of low-permeability formations. Pressure tests of deep water-bearing zones indicated very little mobile water.

BAXTERVILLE, MISSISSIPPI

Project DRIBBLE and the Miracle Play Program were conducted in the Tatum Salt Dome (also known as the SALMON Site). The Tatum Salt Dome interrupts and deforms the lower units of coastal marine deposits in the area, has low permeability, and allows little water movement. Seven hydrologic units are recognized in the area, exclusive of the salt dome and its anhydrite caprock. These are, from the surface downward, the Surficial Aquifer, the Local Aquifer, and Aquifers 1, 2, 3, 4, and 5. These aquifers consist of sands and gravels, sandstones, shales, and limestones with low-permeability clay beds acting as aquitards. The natural flow has been disrupted by pumping from the upper aquifers and by injection of oil-field brines into Aquifer 5. The transient conditions and lack of data result in uncertainties in groundwater flow directions.

GOBERNADOR, NEW MEXICO

Project GASBUGGY is located on the eastern side of the San Juan Basin. The direction of groundwater movement is not well known, but is thought to be to the northwest in the Ojo Alamo sandstone toward the San Juan River. The test was conducted in the underlying Pictured Cliffs sandstone and Lewis Shale, which are not known to yield substantial amounts of water. Therate of groundwater movement in the Ojo Alamo sandstone is estimated to be approximately 0.01 m/yr.

MALAGA, NEW MEXICO

The Project GNOME site is located in the northern part of the Delaware Basin which contains sedimentary rocks and a thick sequence of evaporites. The test was conducted in the halites of the Salado Formation which is overlain by the Rustler Formation, the Dewey Lake Redbeds, and alluvial deposits. The Rustler Formation contains three water-bearing zones; a dissolution residue at its base, the Culebra Dolomite, and the Magenta Dolomite. The Culebra Dolomite is the most regionally extensive aquifer in the area. The groundwater in the Culebra is saline, but is suitable for domestic and stock uses. Groundwater in the Culebra flows to the west and southwest toward the Pecos River.

AREAS OF POSSIBLE GROUNDWATER CONTAMINATION AT THE NTS

In 1996, DOE/NV analyzed and confirmed the location of 908 underground tests in 878 holes at the NTS (Figure 9.1). Approximately one third (259) of these tests were at or below the water table (DOE 1996a). The principal by-products from these tests were heavy metals and a wide variety of

Click to view Figure 9.1

Figure 9.1 Areas of Potential Groundwater Contamination on the NTS radionuclides with differing half-lives and decay products. Detonations within, or near, the regional water table have contaminated the local groundwater with over 60 radionuclides being present in significant quantities. Tritium is the most abundant radionuclide, with an estimated 100 million Curies present in or near the water table (DOE 1996c). Table 9.1 is a listing of routine sampling locations, onsite and offsite, where well water samples contained tritium concentrations greater than 0.2 percent of the National Primary Drinking Water Standards.

Surface activities associated with underground testing and other NTS activities such as disposal of low-level radioactive and mixed wastes, spill testing of hazardous liquefied gaseous fuels, and transport of radioactive materials, also pose potential soil and groundwater contamination risks. The types of possible contaminants found on the surface of the NTS include radionuclides, organic compounds, metals, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as former injection wells, leach fields, sumps, waste storage facilities, tunnel containment ponds and muck piles, and storage tanks, may have contaminated the soil and shallow unsaturated zone of the NTS. The known sites are categorized by type and listed in Appendices II, III, and IV of the Federal Facility Agreement and Consent Order (FFACO), jointly agreed to by DOE, the U. S. Department of Defense (DOD), and the Nevada Division of Environmental Protection (NDEP). The great depths to groundwater and the arid climate mitigate the potential for mobilization of surface and shallow subsurface contamination. However, contaminants entering the carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, underground tests near the water table, and wastes disposed into subsidence craters have the potential to reach groundwater.

GROUNDWATER MONITORING

GROUNDWATER QUANTITY

Water levels are monitored by the U.S. Geological Survey (USGS) on and around the NTS at approximately 156 measurement locations annually. Data for the 1995 water year are reported in Bauer et al., 1996, the most recent publication. Results are used in regional and local groundwater models, but are not routinely analyzed for water level trends. However, no significant water level impacts associated with groundwater usage were detected in 1996.

Water usage on the test site is monitored by the both the USGS and Bechtel Nevada (BN). The data are reported in Bauer et al., 1996. Water use at the test site continues to decline owing to the cessation of underground nuclear testing in 1992 and was about 1.33 x 10^6 m^3 (351 x 10^6 gal) in 1996.

GROUNDWATER QUALITY

Groundwater quality was determined by monitoring wells and springs both onsite and offsite. The results from onsite water supply wells, environmental surveillance for radioactivity in groundwater monitoring wells, and springs are presented in Chapter 4. Results from offsite water supply wells and springs are presented in Section 9. Monitoring of groundwater discharging from the E Tunnel in Area 12 is discussed in Chapter 5. Groundwater monitoring at the Area 5 Radioactive Waste Management Site (RWMS-5) is detailed in Chapter 8. The remainder of this chapter summarizes analyses of water for chemical constituents, radioisotopes, and stable isotopes in order to comply with environmental permits, better characterize NTS groundwater quality, and support regional groundwater flow and transport models.

A monitoring well, SM23-1, was drilled next to the sewage lagoon in Area 23 as part of the general discharge permit for the site (see

Chapter 3). The objectives of the well were to obtain water samples to determine the extent to which liquid from the sewage lagoons had infiltrated into the subsurface, provide data for the computer modeling of sewage lagoon performance, and provide a groundwater monitoring point below the sewage lagoons. Groundwater was encountered at 398 m (1,306 ft) below ground surface and the well was completed in the uppermost water-producing zone. The well was not developed and sampled in 1996.

Groundwater contamination was detected in Pahute Mesa Exploratory Hole #2 in 1993, and the Hydrologic Resources Management Program initiated a multi-organization investigation to determine the source of contamination. Tritium in water at an average level of 6.9×10^{-4} µCi/mL (25.600 Bq/L) was detected at the most contaminated interval 610 m (2,000 ft) below the surface. The data indicate that several possible mechanisms could account for the migration of contamination from the Schooner underground test 270 m (886 ft) to the southeast of the well. The most probable pathway for radionuclides to enter the well water involves contaminated ejecta from the test entering the wellbore soon after the test rather than groundwater migration or prompt injection of radionuclides from the Schooner test (Russell and Locke 1996).

Analysis of groundwater in 18 wells in Yucca Flat for the environmental isotopes $^{2}H/^{1}H$, $^{18}O/^{16}O$, $^{13}C/^{12}C$, $^{14}C/C$, and $^{87}Sr/^{86}Sr$ was reported in 1996. Results indicate that groundwater in Yucca Flat ascends from depth, possibly along a fault, at a calculated rate of about 9 m/yr (30 ft/yr) (Kenneally 1996).

DOE continued efforts to create a long-term monitoring program for wells in or near underground nuclear event cavities. The program objectives are to characterize the hydrologic source term and evaluate the decay and potential migration of radionuclides through monitoring at or near the source. Los Alamos National Laboratory and Lawrence Livermore National Laboratory (LLNL) monitored water at the ALMENDRO, TYBO, BULLION, and CHESHIRE events on Pahute Mesa and the CAMBRIC event in Frenchman Flat (Thompson 1997). A summary report from both laboratories will be released in 1997.

9.2 GROUNDWATER PROTECTION

DOE/NV has instituted a policy regarding protection of the environment. This policy states: "A principal objective of the DOE/NV policy is to assure the minimization of potential impacts on the environment, including groundwater, from underground testing. An ongoing program to monitor and assess the effectiveness of groundwater protection efforts will be enhanced so that resources are allocated based on current understanding of the effectiveness of groundwater protection programs." Groundwater protection activities contained within DOE/NV programs are described below.

WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PROGRAM

The Waste Minimization and Pollution Prevention Awareness Program is designed to reduce waste generation and possible pollutant releases to the environment, increasing the protection of employees and the public. All DOE/NV contractors and NTS users who exceed the EPA criteria for small-quantity generators have established implementation plans in accordance with DOE/NV requirements. Contractor programs ensure that waste minimization activities are in accordance with federal, state, and local environmental laws and regulations and DOE Orders. A discussion of 1996 activities is given in Chapter 3.

SITING FOR UNDERGROUND NUCLEAR TESTS

The draft DOE/NV Procedural Instruction "Siting Criteria for Protection of Groundwater at the Nevada Test Site" (NV PI 97-001) defines five criteria for siting underground nuclear tests based upon the current understanding of the effects of testing on the groundwater environment. Before an emplacement hole or emplacement drift can be used for a test, documentation must be submitted by the sponsoring user to the DOE/NV Assistant Manager for National Security to show compliance with these criteria, which are:

- Future testing should utilize previously used areas of testing.
- Tests with working points at or below the water table should be minimized. Testing within perched water conditions is excluded from this criterion.
- Working points should be placed no closer than two cavity radii from any regional carbonate aquifer.
- Emplacement holes should not be sited within 1,500 m of the NTS boundary where groundwater leaves the NTS.
- Emplacement holes which extend more than two cavity radii or 30 m, whichever is greater, beneath the working point should be plugged to prevent the open borehole from becoming a preferential pathway for groundwater contamination.

WASTE TREATMENT, STORAGE, AND DISPOSAL

DOE/NV currently operates two disposal facilities in Areas 3 and 5 at the NTS for low-level radioactive waste (LLW) generated by DOE and the DOD facilities. The RWMS-5 also serves as a temporary storage area for LLNL transuranic wastes which will be shipped, upon final certification, to the Waste Isolation Pilot Plant in New Mexico for disposal. All hazardous wastes generated at the NTS are stored at a Hazardous Waste Accumulation Site in Area 5 until shipped offsite to EPA-approved commercial disposal facilities. Uranium-ore residues designated as strategic materials are stored north of the RWMS-5. The Area 3 RWMS (RWMS-3) is used for the disposal of nonstandard packaged LLW from offsite and unpackaged bulk wastes from the NTS.

In 1996, one mixed waste shipment, a Nevada-generated shipping cask, was disposed of at RWMS-5. The disposal was in the Pit 3 facility, a Resource Conservation and Recovery Act (RCRA) interim status permitted facility.

In accordance with Title 40 C.F.R. 265 - Subpart F, operators of interim status treatment, storage, and disposal facilities are required to collect quarterly samples for one year from one upgradient and three downgradient wells for characterization of background water quality. Sampling protocols for characterization and detection data collection were based on the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA 1986). Groundwater elevation was measured prior to each sampling event. The first collections of these characterization data were performed in 1993. Subsequent semi-annual sampling was continued through 1996 and results were statistically compared with the initial characterization data.

Based on characterization results during 1993 and detection monitoring results through 1996, the uppermost aquifer beneath the RWMS-5 disposal cells is suitable for use as drinking water or for agricultural purposes. The analyses performed for these samples can be found in Table 9.2. No chemical or radiological contaminants attributable to either DOE weapons testing or waste management activities have been detected in the three wells.

In accordance with DOE Order 5820.2A, "Radioactive Waste Management," DOE/NV prepared and submitted a Performance Assessment (PA) for LLW disposal at the

RWMS-5. In 1996, the DOE Headquarters (DOE/HQ)-appointed Peer Review Panel (PRP) found the RWMS-5 PA to be technically acceptable following a rigorous 15-month review. Comments from the PRP were addressed in addenda to the PA and the final PA is being revised for publication and resubmittal to DOE/HQ in 1997.

The Area RWMS-3 PA is in full progress. Efforts in 1996 focused on hydrogeologic characterization through borehole drilling and sample analysis, surface geologic mapping, flood studies, inadvertent human intruder studies, and source inventory analysis. Characterization boreholes were installed at a slant beneath active surface-subsidence craters where waste is disposed, as well as vertically within the chimney structure of the reserve craters intended for future waste disposal. Completion of the draft RWMS-3 PA is scheduled for 1997.

In April 1996, DOE and the Defense Nuclear Facilities Safety Board agreed that a Composite Analysis (CA) of the pre-1988 waste source term, and all other sources of radioactive contamination in the ground that are potentially interactive with the LLW disposal facility materials, be performed. The CA serves as a long-term management planning tool to evaluate total radiological risk to the public at site-determined compliance points and boundaries. A source-screening assessment was completed for Yucca Flat basin as a first step in preparing the RWMS-3 CA; the CA is scheduled for delivery to DOE/HQ with the PA in 1997. The pre-1988 source inventory for the RWMS-5 CA is in progress and the completed CA is due to DOE/HQ in 1999.

WELLHEAD RECONSTRUCTION AND WELL REHABILITATION

The Hydrologic Resources Management Program completed an investigation of all existing boreholes within one kilometer of underground nuclear tests conducted in the water table or within 50 m of the water table. One objective of the review was to determine if boreholes existed which could provide a pathway for preferential vertical migration of radionuclides associated with nearby tests. A second objective was to identify holes that could be converted into monitoring wells or kept in reserve for potential monitoring use in the future.

Out of approximately 250 wells examined, 40 were determined to meet the distance criteria and were investigated in detail to determine their drilling and construction history, lithology and hydrologic units penetrated, and current conditions. Recommendations were made to plug, recondition, or recomplete the wells.

SEWAGE LAGOON UPGRADES

In 1996, sewage lagoon upgrades were completed which resulted in a lower potential for migration of contaminants to the groundwater. Specific information is contained in Chapter 3.

9.3 ENVIRONMENTAL RESTORATION

The Nevada ERP was begun in the late 1980s to address contamination resulting primarily from nuclear weapons testing and related support operations. The goals of the project are to safeguard the public’s health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. Approximately 878 sites used for historic underground nuclear tests will be investigated, along with areas where more than 100 aboveground tests were conducted. Additionally, 1,500 other sites that were used for support operations will potentially require environmental remediation.

The DOE/NV is working closely with representatives of the state of Nevada to ensure compliance with applicable environmental regulations. A FFACO was signed by the DOE, DOD, and NDEP in May

1996. The FFACO provides a mechanism for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. It also establishes a framework for identifying, prioritizing, investigating, remediating, and monitoring contaminated DOE sites in Nevada. The FFACO's corrective action requirements supersede some portions of the NTS RCRA Permit issued in May 1995.

Investigations and remediations follow a strategy for investigation and remediation outlined in Appendix VI, Corrective Action Strategy, of the FFACO. The strategy is based on four steps: (1) identifying corrective action sites, (2) grouping the sites into corrective action units, (3) prioritizing the units for funding and work, and (4) implementing investigations or actions as applicable. The sites are broadly organized into underground test area sites, industrial sites, soil sites, and off sites. Information related to investigation and cleanup activities as it relates to groundwater protection follows.

UNDERGROUND TEST AREA (UGTA) SITES

The UGTA Project focused on drilling, testing, and sampling wells near underground nuclear tests. The drilling program was conducted in order to determine radiochemical and hydrogeologic conditions near tests in support of modeling at the scale of Corrective Action Units. Contaminated fluid produced during drilling and sampling was managed in accordance with the UGTA Waste Management Plan to prevent degradation of groundwater. Evaporation of tritiated water from the drilling operations is included in the calculations for compliance with the National Emissions Standard for Hazardous Air Pollutants.

Accomplishments of the UGTA project in 1996 include the completion, development, and sampling of two wells at the TYBO underground nuclear test and three wells at the BULLION test on Pahute Mesa. Other activities included the development and sampling of one zone in well ER-3-1 in Yucca Flat and two zones in well ER-30-1 on Buckboard Mesa. In general, results show no evidence of man-made radionuclides in the Yucca Flat and Buckboard Mesa wells, and expected levels of contamination in the near-event wells on Pahute Mesa. Results are scheduled for publication in 1997.

INDUSTRIAL SITES AND DECONTAMINATION AND DECOMMISSIONING

CLOSURE IN PLACE OF CORRECTIVE ACTION UNIT NO. 90: AREA 2 BITCUTTER AND POSTSHOT CONTAINMENT SHOPS INJECTION WELLS

The Bitcutter and Postshot Containment Shop injection wells are located in Area 2 at the NTS. Three wells were installed for disposal of fluids used during shop operations for several years during the early 1980s. Two wells are associated with the Bitcutter shop (one inside and one outside) and one is associated with the Postshot Containment Shop.

In 1995, DOE/NV ERP concluded characterization activities which included drilling 15 investigative boreholes, downhole video inspection within the inside Bitcutter Shop well, and sampling the sludge contained in the Postshot Injection well. The results for the inside Bitcutter Shop well indicated concentrations of Total Petroleum Hydrocarbon (TPH) above the NDEP action level of 100 ppm and RCRA-listed wastes present at trace levels above regulatory thresholds. Soil samples taken at the Postshot and outside Bitcutter Shop wells indicated TPH levels below regulatory levels. No radiological contamination was found at any of the three wells.

The method of closure for the Postshot Injection well was to remove any liquid or sludge from the hole, grout the casing, and place a concrete cap on top of the well. The inside Bitcutter Shop well was plugged with cement and a concrete cap was placed above the well. No further action was taken on the outside Bitcutter Shop well since the casing and TPH-impacted soil were removed during characterization. The well caps are six inches above the ground surface and sloped to promote runoff of precipitation. These facilities and other NTS facilities with RCRA closure plans are listed in Table 9.3.

ABANDONED UNDERGROUND STORAGE TANKS

Nine abandoned underground storage tanks were removed from various areas of the NTS.

SOIL SITES

In 1996, radiologically contaminated soils from the DOUBLE TRACKS site, on the Nellis Air Force Range Complex, northwest of the NTS were removed and disposed of in Area 3 on the NTS. However, these contaminated soils were at the ground surface and did not contaminate the subsurface or groundwater. Therefore, they are not discussed further here.

OFFSITE LOCATIONS

The offsite areas are described in Section 9.1 of this chapter. Activities related to groundwater protection at these sites are conducted as part of the ERP. Investigation and cleanup at these sites are being conducted in accordance with the FFACO with the state of Nevada for the two sites in Nevada, SHOAL and FAULTLESS. In the remainder of the states, agreements will be developed as the restoration activities proceed. Following is a summary of activities at sites where activities were conducted during 1996.

At the Project SHOAL site, an investigation plan was completed and approved, four monitoring wells were installed, and shallow soil sampling in the mudpits was completed.

At the Project RULISON site, an assessment of radionuclide movement from the site was completed by the Desert Research Institute (DRI) (Earman et al., 1996a). A voluntary, interim remedial action was completed in cooperation with the state of Colorado. Approximately 14,000 m^3 (3.7 million gal) of water was removed from the pond occupying the former mudpit and 18,600 m^3 (24,400 yd^3) of TPH-contaminated sediment was excavated, stabilized, transported, and disposed of. The pond was lined and restored. Soil test borings were completed and monitoring wells were drilled to allow long-term monitoring. The final corrective action report and risk assessment were submitted to the state of Colorado for approval.

At the RIO BLANCO site, historical information and data were compiled and evaluated. An assessment of radionuclide movement from the site was completed by the DRI (Chapman et al., 1996a).

At the Project GNOME site, historical information and data were compiled and evaluated. The DRI reported on historical tracer tests (Pohll and Pohlmann 1996) and performed a preliminary risk assessment (Earman et al., 1996b).

At the Project GASBUGGY Site, historical information and data was compiled and evaluated. The DRI assessed radionuclide movement from the site (Chapman et al., 1996b).

At the Project DRIBBLE (SALMON) site, access roads were repaired, a waste management facility was constructed, and 13 new shallow groundwater monitoring wells were installed and logged.

9.4 LONG-TERM HYDROLOGICAL MONITORING PROGRAM (LTHMP)

The EPA's Radiation and Indoor Environments National Laboratory in Las Vegas (R&IE-LV) is responsible for operation of the LTHMP, including sample collection, analysis, and data reporting. From the early 1950s until implementation of the LTHMP in 1972, monitoring of ground and surface waters was done by the U.S. Public Health Service (PHS), the USGS, and the U.S. Atomic Energy Commission (AEC) contractor organizations. The LTHMP consists of routine radiological monitoring, analysis, and reporting of samples collected from specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS. Samples are also collected from sites in Nevada, Colorado, New Mexico, Mississippi, and Alaska where nuclear tests have been conducted. In 1965, tritium escaped from the LONG SHOT test on Amchitka Island and contaminated the shallow groundwater, and during cleanup and disposal operations, shallow groundwater at the Tatum Dome Test Site in Mississippi was contaminated with tritium. The tritium concentration in water at both of these sites has steadily decreased and was well below the drinking water standard when last sampled.

A discussion of LTHMP sampling and analysis procedures, and the locations sampled is provided below. Summaries of the 1996 sampling results for each of the offsite LTHMP locations is provided in Section 9.6. More detailed sampling results for the LTHMP are being published separately in the "Environmental Data Report for the Nevada Test Site - 1996," (DOE/NV/11718-138, in prep.).

SAMPLING AND ANALYSIS PROCEDURES

The procedures for the analysis of samples collected for this report are described by Johns et al., 1979 and are summarized in Table 9.4. These include gamma spectral analysis and radiochemical analysis for tritium. The procedures are based on a standard methodology for the stated analytical procedures. Two methods for tritium analysis were performed: conventional and electrolytic enrichment. The samples were initially analyzed for tritium by the conventional method followed by enrichment analysis if the results were less than 700 pCi/L (26 Bq/L). In late 1995, it was decided that only 25 percent of the samples would be analyzed by the electrolytic enrichment method. The samples selected have a tritium result of less than 700 pCi/L by the conventional method and are from locations that are in position to show possible migration. Two 250-mL glass bottles and a 1-gal plastic container are filled at each sampling location. At the sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured and recorded when the sample is collected. For wells with operating pumps, the samples were collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling unit is used. With this unit, it is possible to collect 3-L samples from wells as deep as 1,800 m (5,900 ft).

The first time samples are collected from a well, $^{89,90}Sr$, $^{238,239+240}Pu$, and uranium isotopes are determined by radiochemical analysis, in addition to analysis mentioned above. The 250-mL samples are analyzed for tritium and the 1-gal sample from each site is analyzed by gamma spectrometry.

ACTIVITIES ON AND AROUND THE NEVADA TEST SITE

NEVADA TEST SITE MONITORING

The present sample locations on the NTS, or immediately outside its borders on federally owned land are shown in Figure 9.2. All sampling locations are selected by DOE and primarily represent potable water supplies. In 1995, sampling on the NTS was modified so that EPA only samples wells without pumps and, for Quality Assurance purposes,

Click to view Figure 9.2

Figure 9.2 Wells on the NTS Included in the LTHMP - 1996 collects samples from 10 percent of the potable wells sampled by BN. A total of 21 wells was scheduled to be sampled, but only 19 wells were sampled for various reasons.

All samples were analyzed by gamma spectrometry and for tritium. No gamma-emitting radionuclides were detected in any of the NTS samples collected in 1996. Summary results of tritium analyses are given in Table 9.5. The highest average tritium activity was 4.5 x 10^4 pCi/L (1,700 Bq/L) in a sample from Well UE-5n. This activity is less than 60 percent of the Derived Concentration Guide (DCG) for tritium established in DOE Order 5400.5 for comparison with the dose limit (4 mrem) in the National Primary Drinking Water Regulations. Eight of the wells sampled yielded tritium results greater than the minimum detectable concentration (MDC). The trend in tritium concentration in samples from Test Well B is shown in Figure 9.3 and is typical of a well with decreasing tritium concentrations. Well UE-7ns was routinely sampled between 1978 and 1987 and sampling began again in 1992. An increasing trend in tritium activity was evident at the time sampling ceased in 1987. Recent results have shown a decrease from those previous results, although the present result is higher than results for 1995.

OFFSITE MONITORING IN THE VICINITY OF THE NEVADA TEST SITE

The monitoring sites in the area around the NTS are shown in Figure 9.4. Most of the sampling locations represent drinking water sources for rural residents or public drinking water supplies for the communities in the area. The sampling locations include 12 wells, 9 springs, and a surface water site. All of the locations are sampled quarterly or semiannually. Gamma spectrometric analyses are performed on the samples when collected. No man-made gamma-emitting radionuclides were detected in any sample. Tritium analyses are performed on a semiannual basis. Adaven Spring is the only site which consistently shows detectable tritium activity. The tritium activity in this spring represents environmental levels that have been decreasing over time. All results for this project for 1996 are shown in Table 9.6.

9.5 LTHMP AT OFF-NTS NUCLEAR DEVICE TEST LOCATIONS

Sampling for the LTHMP is conducted at sites of past nuclear device testing in other parts of the United States to ensure the safety of public drinking water supplies and, where suitable sampling points are available, to monitor any migration of radionuclides from the test cavity. Annual sampling of surface and ground waters is conducted at the Projects SHOAL and FAULTLESS sites in Nevada, the Projects GASBUGGY and GNOME sites in New Mexico, the Projects RULISON and RIO BLANCO sites in Colorado, and the Project DRIBBLE (SALMON) site in Mississippi. Sampling is normally conducted in odd numbered years on Amchitka Island, Alaska, and at the site of Projects CANNIKIN, LONG SHOT, and MILROW. Sampling was not done in 1995 due to lack of funding.

The sampling procedure is the same as that used for sites on the NTS and offsite areas (described in Section 9.4), with the exception that two 3.8-L samples are collected in Cubitainers. The second sample serves as a backup or as a duplicate sample.

Because of the variability noted in past years in samples from the shallow monitoring wells near Project DRIBBLE (SALMON) ground zero (GZ), the sampling procedure as modified several years ago. A second sample is taken after pumping for a specified period of time or after the well has been pumped dry and permitted to recharge. These second samples may be representative of formation water, whereas the first samples may be more indicative of recent rainfall.

Click to view Figure 9.3

Figure 9.3 Tritium Concentration Trends in Test Well B on the NTS

PROJECT FAULTLESS

Project FAULTLESS was a "calibration test" conducted on January 19, 1968, in a sparsely populated area near Blue Jay Maintenance Station, Nevada. The test had a yield between 200 and 1,000 kt and was designed to test the behavior of seismic waves and to determine the usefulness of the site for high-yield tests. The emplacement depth was 975 m (3,199 ft). A surface crater was created, but as an irregular block along local faults rather than as a saucer-shaped depression. The area is characterized by basin and range topography, with alluvium overlying tuffaceous sediments. The working point of the test was in tuff. The groundwater flow is generally from the highlands to the valley and through the valley to Twin Springs Ranch and Railroad Valley (Chapman and Hokett 1991).

Sampling was conducted on March 6 and 7, 1996, at locations shown in Figure 9.5. Routine sampling locations include one spring and five wells of varying depths. The Bias Well was not sampled because the ranch was closed and Six Mile Well was not sampled because the pump was removed. A new sampling location (site C Complex) was established to replace the Bias Ranch Well. This site is approximately 8 mi from Blue Jay Maintenance Station and is approximately 20 mi from surface ground zero (SGZ).

At least two wells (HTH-1 and HTH-2) are positioned to intercept migration from the test cavity, should it occur (Chapman and Hokett 1991). All samples yielded negligible gamma activity.

Tritium concentrations were less than the MDC. These results are all consistent with results obtained in previous years. The

Click to view Figure 9.4

Figure 9.4 Wells Outside the NTS Included in the LTHMP - 1996

Click to view Figure 9.5

Figure 9.5 LTHMP Sampling Locations for Project FAULTLESS - 1996 results for tritium indicate that, to date, migration into the sampled wells has not taken place and no event-related radioactivity has entered area drinking water supplies.

PROJECT SHOAL

Project SHOAL, a 12-kt test emplaced at 365 m (1,198 ft), was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada. The test, part of the Vela Uniform Program, was designed to investigate detection of a nuclear detonation in an active earthquake zone. The working point was in granite and no surface crater was created. An effluent was released during drillback but was detected onsite only and consisted of 110 Ci of ^{131}Xe and ^{133}Xe, and less than 1.0 Ci of ^{131}I.

Samples were collected on March 4 and 5, 1996. The sampling locations are shown in Figure 9.6. Only five of the seven routine wells were sampled. No sample was collected from Spring Windmill because the pump was removed. No sample was collected from Well H-2 because the well was locked and no key was available to EPA at the time of sampling. The routine sampling locations include one spring, one windmill, and five wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migrating from the test cavity, should it occur (Chapman and Hokett 1991). Gamma-ray spectral analysis results indicated that no man-made gamma-emitting radionuclides were present in any samples above the MDC. All tritium results were also below the MDC.

PROJECT RULISON

Cosponsored by the AEC and Austral Oil Company under the Plowshare Program, Project RULISON was designed to stimulate natural gas recovery in the Mesa Verde formation. The test, conducted near Grand Valley, Colorado, on September 10, 1969, consisted of a 40-kt nuclear explosive emplaced at a depth of 2,568 m (8,425 ft). Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972 and the wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Contaminated soil was removed during the cleanup operations.

Sampling was conducted June 4-7, 1996, with collection of samples from eight out of nine wells in the area of Grand Valley and Rulison, Colorado. The spring 300 yards from SGZ was dry. Routine sampling locations are shown in Figure 9.7, including the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and three sites in the vicinity of SGZ, including one test well, a surface-discharge spring which was dry and a surface sampling location on Battlement Creek. Seven new monitoring wells were completed at the RULISON Site in 1995 as part of the Remedial Investigation and Feasibility Study. These wells will be added to the LTHMP in 1998.

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites show detectable levels of tritium, which have generally exhibited a stable or decreasing trend over the last two decades. The range of tritium activity in 1996 was from 242 ± 140 pCi/L (9 Bq/L) at Battlement Creek, to 112 ± 6.9 pCi/L (4.1 Bq/L) at Lee Hayward Ranch. All values were less than 1 percent of the DCG. The detectable tritium activities were probably a result of the high natural background in the area. This was supported by the DRI analysis, which indicated that most of the sampling locations were shallow, drawing water from the surficial aquifer which was unlikely to become contaminated by any radionuclides arising from the Project RULISON cavity (Chapman and Hokett 1991). All samples were analyzed for presence of gamma-ray emitting radionuclides. None were detected above the MDC.

Click to view Figure 9.6

Figure 9.6 LTHMP Sampling Locations for Project SHOAL - 1996

Click to view Figure 9.7

Figure 9.7 LTHMP Sampling Locations for Project RULISON - 1996

PROJECT RIO BLANCO

Project RIO BLANCO a joint government-industry test designed to stimulate natural gas flow was conducted under the Plowshare Program. The test was conducted on May 17, 1973, at a location between Rifle and Meeker Colorado. Three nuclear explosives with a total yield of 99 kt were emplaced at 1780-, 1920-, and 2040-m (5840-, 6299-, and 6693-ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued to 1976 when cleanup and restoration activities were completed. Tritiated water produced during testing was injected to 1710 m (5610 ft) in a nearby gas well.

Samples were collected June 6 and 7, 1996, from the sampling sites shown in Figure 9.8. Only 13 of the 14 routine wells were sampled. No sample was collected from Brennan Windmill because the pump was inoperable. The sample taken from CER #1; was lost in transit. The routine sampling locations included three springs and six wells. Three of the wells are located near the cavity and at least two of the wells (Wells RB-D-01 and RB-D-03) were suitable for monitoring possible migration of radioactivity from the cavity.

No radioactive materials attributable to the RIO BLANCO test were detected in samples collected in the offsite areas during June 1996. Three of the eleven samples collected were above the MDC for tritium and the rest were less than the MDC. The tritium concentrations are well below 20,000 pCi/L level defined in the EPA National Primary Drinking Water Regulations (Title 40 C.F.R. 141). All samples were analyzed for presence of gamma-ray emitting radionuclides, and none were detected. The tritium concentrations were consistent with those collected previously at this site.

PROJECT GNOME

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test performed in a salt formation. A slightly more than 3-kt nuclear explosive was emplaced at 371 m (1217 ft) depth in the Salado salt formation. Radioactive gases were unexpectedly vented during the test. The USGS conducted a tracer study in 1963, involving injection of 20 Ci ^{3}H, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I (740, 370, 370, and 150 GBq, respectively) into Well USGS-8 and pumping water from Well USGS-4. During cleanup activities in 1968-69, contaminated material was placed in the test cavity access well. More material was slurried into the cavity and drifts in 1979.

Sampling at Project GNOME was conducted June 22 - 25, 1996. The routine sampling sites, depicted in Figure 9.9, include nine monitoring wells in the vicinity of GZ and the municipal supplies at Loving and Carlsbad, New Mexico. Stock tanks at wells PHS 8, PHS 9, and PHS 10, were sampled at the request of DOE. Tritium results from stock tank PHS 8 was greater than the MDC. The remaining two were below the MDC.

Tritium results greater than the MDC were detected in water samples from seven of the nine sampling locations in the immediate vicinity of GZ. Tritium activities in Wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from 5 x 10^{3} pCi/L (185 Bq/L) in Well LRL-7 to 6.8 x 10^{7} pCi/L (2.5 MBq/L) in Well DD-1. Well DD-1 collects water from the test cavity; Well LRL-7 collects water from a sidedrift; and Wells USGS-4 and -8 were used in the radionuclide tracer study conducted by the USGS. None of these wells are sources of potable water.

In addition to tritium, ^{137}Cs and ^{90}Sr concentrations were observed in samples from Wells DD-1, LRL-7, and USGS-8 and ^{90}Sr activity was detected in Well USGS-4 as in previous years (see Table 9.1). The remaining two wells with detectable tritium concentrations were PHS-6 and -8, with results less than 0.02 percent of the DCG. No tritium was detected in the remaining sampling locations, including Well USGS-1, which the DRI analysis (Chapman and Hokett 1991) indicated is positioned to detect any migration of radioactivity from the cavity.

Click to view Figure 9.8

Figure 9.8 LTHMP Sampling Locations for Project RIO BLANCO - 1996

Click to view Figure 9.9

Figure 9.9 LTHMP Sampling Locations for Project GNOME - 1996

PROJECT GASBUGGY

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. Government and El Paso Natural Gas. Conducted near Farmington, New Mexico, on December 10, 1967, the test was designed to stimulate a low productivity natural gas reservoir. A nuclear explosive with a 29-kt yield was emplaced at a depth of 1,290 m (4,240 ft). Production testing was completed in 1976 and restoration activities were completed in July 1978.

The principal aquifers near the test site are the Ojo Alamo sandstone, an aquifer containing non-potable water located above the test cavity and the San Jose formation and Nacimiento formation, both surficial aquifers containing potable water. The flow regime of the San Juan Basin is not well known, although it is likely that the Ojo Alamo sandstone discharges to the San Juan River 50 mi northwest of the GASBUGGY site. Hydrologic gradients in the vicinity are downward, but upward gas migration is possible (Chapman and Hokett 1991).

Sampling at GASBUGGY was conducted during June 1996. Only ten samples were collected at the designated sampling locations shown in Figure 9.10. The Bixler Ranch has been sealed up and the pond north of Well 30.3.32.343N was dry.

The three springs sampling sites yielded tritium activities of 26 ± 4.3 pCi/L for Bubbling Springs, 43 ± 4.0 pCi/L for Cedar Springs, and 54 ± 6.2 pCi/L for Cave Springs (0.96, 1.6, and 2.0 Bq/L, respectively), which were less than 0.2 percent of the DCG and similar to the range seen in previous years. Tritium samples from the three shallow wells were all below the average MDC.

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity, with a sampling depth of approximately 1,100 m (3,600 ft), has yielded detectable tritium activities since 1984. The sample collected in June 1996 contained tritium at a concentration of 130 ± 5.2 pCi/L (4.8 Bq/L). The migration mechanism and route is not currently known, although an analysis by DRI indicated two feasible routes, one through the Printed Cliffs sandstones and the other one through the Ojo Alamo sandstone, one of the principal aquifers in the region (Chapman et al., 1996b). In either case, fractures extending from the cavity may be the primary or a contributing mechanism.

All gamma-ray spectral analysis results indicated that no man-made gamma-emitting radionuclides were present in any offsite samples. Tritium concentrations of water samples collected onsite and offsite are consistent with those of past studies at the GASBUGGY site.

PROJECT DRIBBLE (SALMON)

Project DRIBBLE was comprised of two nuclear and two gas explosive tests, conducted in the SALMON test site area of Mississippi under the Vela Uniform Program. The purpose of Project DRIBBLE was to study the effects of decoupling on seismic signals produced by nuclear explosives tests. The first test, SALMON, was a nuclear device with a yield of about 5.3 kt, detonated on October 22, 1964, at a depth of 826 m (2,710 ft). This test created the cavity used for the subsequent tests, including STERLING, a nuclear test conducted on December 3, 1966, with a yield of 380 tons, and the two gas explosions, DIODE TUBE (on February 2, 1969) and HUMID WATER (on April 19, 1970). The ground surface and shallow groundwater aquifers were contaminated by disposal of drilling muds and fluids in surface pits. The radioactive contamination was primarily limited to the unsaturated zone and upper, nonpotable aquifers. Shallow wells, labeled HMH wells on Figure 9.11, have been added to the area near surface GZ to monitor this contamination. In addition to the monitoring wells near GZ, extensive sampling of water wells is conducted in the nearby offsite area as shown in Figure 9.12.

Click to view Figure 9.10

Figure 9.10 LTHMP Sampling Locations for Project GASBUGGY - 1996

Click to view Figure 9.11

Figure 9.11 LTHMP Sampling Locations for Project DRIBBLE (SALMON), Near Ground Zero - 1996

Click to view Figure 9.12

Figure 9.12 LTHMP Sampling Locations for Project DRIBBLE (SALMON), Towns and Residences - 1996

Of the twenty-eight wells that are sampled on the SALMON test site, five regularly have tritium values above those expected in surface water samples. In the 52 samples collected from offsite sampling locations, tritium activities ranged from less than the MDC to 28 pCi/L (1.0 Bq/L), 0.02 percent of the DCG. These results do not exceed the natural tritium activity expected in rainwater in the area. In general, results for each location were similar to results obtained in previous years. Long-term decreasing trends in tritium concentrations are evident only for those locations that had detectable tritium activity at the beginning of the LTHMP, such as in the samples from the Baxterville City Well depicted in Figure 9.13 and Well HM-S shown in Figure 9.14.

Due to the high rainfall in the area, the normal sampling procedure is modified for the shallow onsite wells as described in Section 9.5. Of the 32 locations sampled onsite (20 sites sampled twice), 14 yielded tritium activities greater than the MDC ineither the first or second sample. Of these, eight yielded results higher than normal background (approximately 60 pCi/L [2.2 Bq/L]) as shown in Table 9.1. The locations where the highest tritium activities were measured generally correspond to areas of known contamination. Decreasing trends are evident for the wells where high tritium activities have been found, such as Well HM-S depicted in Figure 9.14. No tritium concentrations above normal background values were detected in any offsite samples. Man-made gamma-ray emitting radionuclides were not detected in any sample collected in this study.

Results of sampling related to Project DRIBBLE (SALMON) are discussed in greater detail in Onsite and Offsite Environmental Monitoring Report, "Radiation Monitoring around SALMON Test Site," Lamar County, Mississippi, April 1996 (Davis 1996, available from R&IE-LV).

AMCHITKA ISLAND, ALASKA

Sampling is normally conducted biennially on odd years but a low budget prevented collection during 1995. The next sampling is scheduled for 1997.

Click to view Figure 9.13

Figure 9.13 Tritium Results Trends in Baxterville, Public Drinking Water Supply - 1996

Click to view Figure 9.14

Figure 9.14 Tritium Results in Well HM-S, SALMON Site, Project DRIBBLE - 1996

Table 9.1 Locations with Detectable Man-Made Radioactivity - 1996[(a)]

Sampling Location	Radionuclide	Concentration x 10^{-9} µCi/mL
NTS Onsite Network		
Well PM-1	^{3}H	200
Well UE-5n	^{3}H	45,000
Well UE-6d	^{3}H	700
Well UE-7ns	^{3}H	500
Well UE-18t	^{3}H	200
Project DRIBBLE, Mississippi (B)		
Well HMH-1	^{3}H	2,100
Well HMH-2	^{3}H	230
Well HMH-5	^{3}H	1,200
Well HM-L	^{3}H	1,200
Well HM-S	^{3}H	4,400
Half Moon Creek Overflow	^{3}H	210
REECo Pit B	^{3}H	240
REECo Pit C	^{3}H	260
Project GNOME, New Mexico		
Well DD-1	^{3}H	6.8×10^{7}
	^{90}Sr	10,000
	^{137}Cs	7.3×10^{5}
Well LRL-7	^{3}H	5,300
	^{90}Sr	2.1
	^{137}Cs	100
Well USGS-4	^{3}H	90,000
	^{90}Sr	3,500
	^{137}Cs	<5.6
Well USGS-8	^{3}H	77,000
	^{90}Sr	4,000
	^{137}Cs	6.8

(a) Only ^{3}H concentrations greater than 0.2 percent of the 4 mrem DCG are shown (i.e., greater than 1.6×10^{-7} µCi/mL [160 pCi/L {6 Bq/L}]). Detectable levels of other man-made radioisotopes are also shown.

Table 9.2 Groundwater Monitoring Parameters at the RWMS-5

Parameters Determining Suitability of Groundwater

Total and Dissolved Metals - As, Ba, Cd, Cr, Hg, Ag, Pb, Se
Total and Dissolved Gross Alpha/Beta

Parameters Establishing Water Quality

Chloride
Total and Dissolved Fe, Mn, Na
Phenols
Sulfate

Indicators of Contamination

pH
Conductivity
Total Organic Carbon
Total Organic Halogen

Additional Selected Parameters

Volatile Organics (8270)
Tritium

Table 9.3 NTS Facilities with RCRA Closure Plans

Area	Designation
Area 2	Bitcutter Shop & LLNL Post Shot Shop
Area 2	U-2bu Subsidence Crater
Area 3	U-3fi Injection Well (closed)
Area 6	Decontamination Facility Evaporation Pond
Area 6	Steam Cleaning Effluent Pond
Area 23	Building 650 Leachfield
Area 23	Hazardous Waste Trenches (closed)
Area 27	Explosive Ordnance Disposal Facility (closed)

Table 9.4 Summary of EPA Analytical Procedures - 1996

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Sample Size	Approximate Detection Limit[(a)]
HpGe Gamma[(b)]	HpGe detector calibrated at 0.5 keV/ channel	100	Radionuclide concentration quantified from gamma spectral data by online computer program.	3.5L	Varies with radionuclides and detector used, ^{137}Cs 7 pCi/L
^{3}H	Automatic liquid scintillation counter	300	Sample prepared by distillation.	5-10 mL	300 to 700 pCi/L
^{3}H+ Enrichment	Automatic liquid scintillation counter	300	Sample concentrated by electrolysis followed by distillation.	250 mL	5 pCi/L

(a) The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE 1981).
(b) Gamma spectrometry using a high purity intrinsic germanium (HpGe) detector.

Table 9.5 LTHMP Summary of Tritium Results for NTS Network - 1996

Tritium Concentration (pCi/L)

Location	Number	Maximum	Minimum	Arithmetic Mean	1 Sigma	Mean as %DCG[(a)]	Mean MDC
Test Well B	1	230	230	230	70	0.26	220
Test Well D	1	38	38	38	70	(b)	220
Well UE-6d	2	724	633	680	180	0.75	110
Well UE-6e	2	190	170	180	67	(b)	210
Well UE-7ns	2	496	466	480	160	0.53	210
Well UE-16f	1	8.1	8.1	8.1	1.7	0.01	5.5
Well UE-18r	2	230	28	130	67	(b)	210
Well UE-18t	1	220	220	220	3.5	0.24	7.0
Well 6A Army	2	3.3	-1.3	1.0	0.35	(b)	4.2
Well HTH-1	1	-77	-77	-77	70	(b)	230
Well PM-1	1	210	210	210	3.1	0.23	6.0
Well U3CN-5	0	Packer In Hole					
Well UE-1c	2	114	93	100	62	(b)	210
Well UE-15d		Pump Inoperative					
Well HTH "F"	1	93	93	93	65	(b)	240
Well C-1	1	270	270	270	68	0.30	220
Well 1 Army	1	-77	-77	-77	68	(b)	230
Well 5B	2	1.8	77	39	20	(b)	110
Well 5C	2	38	0.18	19	10	(b)	110
Well UE-5n	2	52500	38100	45000	13000	50	210
Well J-13	1	77	77	77	70	(b)	230

Note: Conventional and/or enrichment tritium analysis techniques were used for the samples summarized in this table.

(a) DCG - Derived Concentration Guide; established by DOE Order as 90,000 pCi/L for water.
(b) NA - Not applicable; percent of concentration guide is not applicable as the tritium result is less than the MDC or the water is known to be nonpotable.

Table 9.6 LTHMP Summary of Tritium Results for Wells Near the NTS - 1996

Location	Number of Samples[a]	Max.	Min.	Mean	1 s.d.	% of DCG[b]	Mean MDC
		Tritium Concentration (pCi/L)					
Adaven							
Adaven Spring	2	28	19	22	1.7	0.02	5.1
	2	110	0	55	67	(c)	220
Alamo							
Well 4 City	1	--	--	-2.3	3.0	(c)	10
	1	--	--	39	68	(c)	220
Ash Meadows							
Crystal Pool	3	2.9	-2.9	-0.3	1.9	6.3	
	1	--	--	150	67	(c)	210
Fairbanks Spring	2	0.33	-1.1	-0.8	1.7	(c)	5.8
	0						
17S-50E-14cac	1	--	--	0.8	1.8	(c)	5.8
	1	--	--	0	68	(c)	220
Well 18S-51E-7db	1	--	--	1.0	1.4	(c)	4.3
	1	--	--	39	68	(c)	220
Beatty							
Low Level Waste Site	1	--	--	6.2	1.8	<0.01	5.9
	3	190	0	94	65	(c)	220
Tolicha Peak	1	--	--	-2.8	1.6	(c)	5.4
	3	110	0	57	66	(c)	220
11S-48E-1dd Coffer's	1	--	--	-0.6	1.6	(c)	5.4
	3	150	38	110	67	(c)	220
12S-47E-7dbd City	1	--	--	-1.0	2.2	(c)	7.5
	1	--	--	0	68	(c)	220
Younghans Ranch House Well	0						
	3	190	-77	59	67	(c)	220
Boulder City							
Lake Mead Intake	1	--	--	40	1.8	0.04	4.9
	0						
Clark Station							
TTR Well 6	0						
	2	56	39	48	67	(c)	220
Goldfield							
Klondike #2 Well	0						
	2	39	-38	0.5	140		220

(a) For each sample: First row is from enrichment analysis, second row from conventional analysis.

(b) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.

(c) Not applicable. Percent of concentration guide is not applicable because the result is less than the MDC or the water is known to be nonpotable.

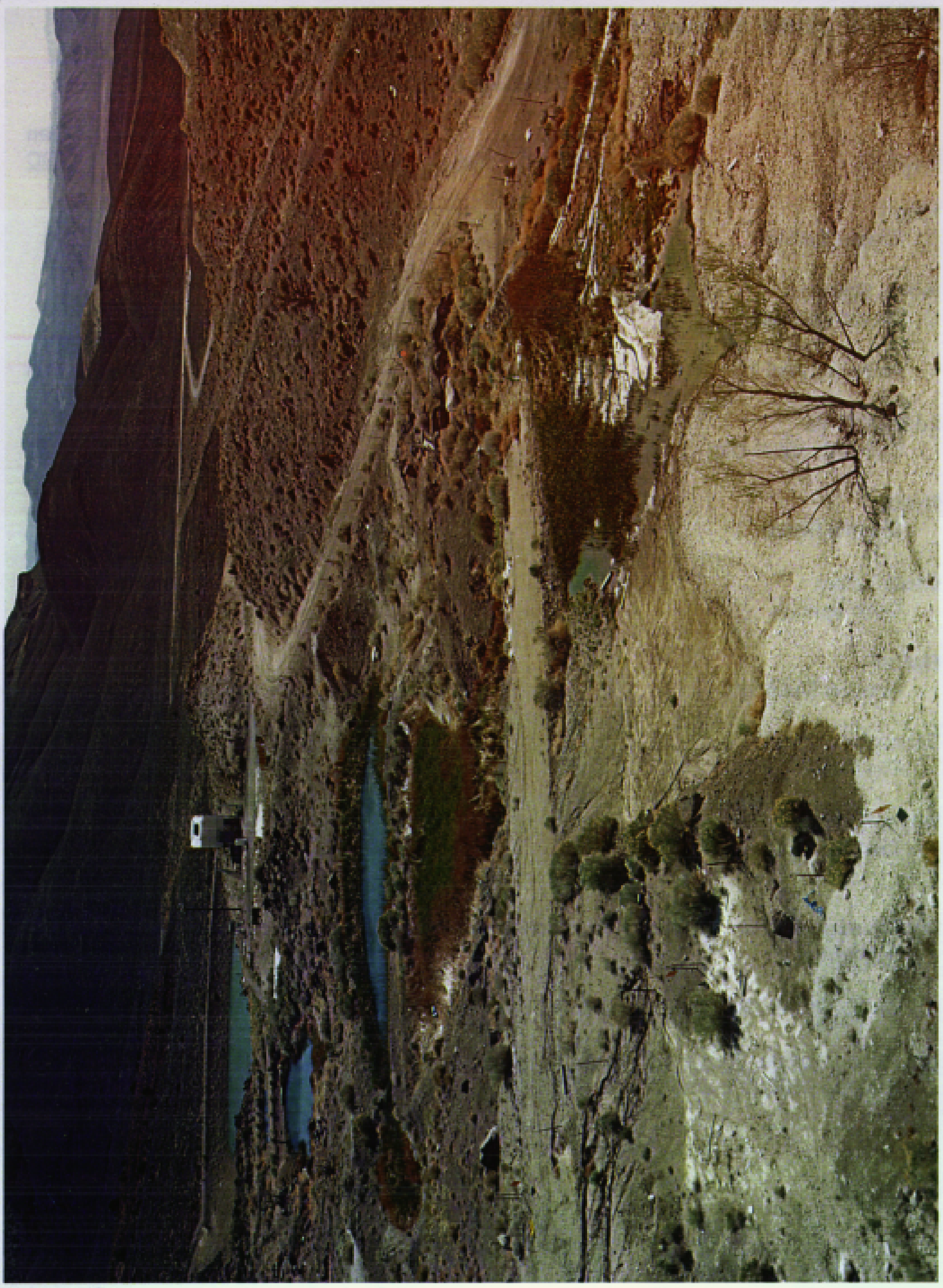
Table 9.6 (LTHMP Summary of Tritium Results for Wells Near the NTS - 1996, cont.)

Location	Number of Samples[a]	Tritium Concentration (pCi/L) Max.	Min.	Mean	1 s.d.	% of DCG	Mean MDC
Hiko							
Crystal Springs	1	--	--	-1.7	3.1	(c)	10
	1	--	--	0	68	(c)	220
Indian Springs							
Sewer Co. Well 1	0						
	1	--	--	0	68	(c)	220
Air Force Well 2	1	--	--	2.6	1.3	(c)	4.3
	1	--	--	0	68	(c)	220
Lathrop Wells							
15S-50E-18cdc City	1	--	--	-0.08	1.2	(c)	4.0
	1	--	--	0	68	(c)	220
Nyala							
Sharp's Ranch	1	--	--	2.0	3.2	(c)	10
	1	--	--	0	68	(c)	220
Oasis Valley							
Goss Springs	DRY						
Rachel							
Penoyer Culinary	1	--	--	1.2	1.4	(c)	4.8
	3	150	56	95	67	(c)	210
Tonopah							
City Well	0						
	2	39	-19	10	66	(c)	220
Warm Springs							
Twin Springs Ranch	1	--	--	0.6	1.3	(c)	4.3
	3	470	56	320	67	(c)	220

(a) For each sample: First row is from enrichment analysis, second row from conventional analysis.

(b) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.

(c) Not applicable. Percent of concentration guide is not applicable because the result is less than the MDC or the water is known to be nonpotable.



Area 3 Tunnel Ponds